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The impact of the addition of hydrogen on the gas distribution grid and consumer equipment

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SUMMARY

Hydrogen as a sustainable energy carrier is currently in the spotlight. In response to questions from the European Commission, the member states are investigating the possibilities of existing gas networks for transporting hydrogen (*Hydrogen Roadmap Europe* and *ENTSOG 2050 roadmap for renewable gas*).
Gas networks are capable to transport high capacities at relatively low costs. In addition, the Netherlands has a very extensive gas transport and gas distribution network (> 94% of Dutch households have a gas connection). For these reasons, the gas networks in the Netherlands play an important role in the energy transition.

The research question discussed in this report is what impact the admixture of hydrogen can have on the gas distribution network and consumer equipment. No comparison was made in the analysis with other sustainability options.

To answer this question, a lot of studies on admixing hydrogen in the natural gas grid have been examined.

What is already possible?
Mixing hydrogen with natural gas seems technically possible for most applications up to 3 vol%. It should be noted here that most existing appliances have not been tested for this level. Safety aspects will have to be covered for these devices, for example by drawing up a risk analysis. In addition, current regulations do not provide for percentages higher than 0.5 vol% hydrogen in natural gas and will therefore have to be adjusted to 3 vol%.

What is possible in the long term?
Growth to 20 vol% hydrogen seems possible. However, many commercial and industrial gas applications, such as gas turbines and gas engines, have limitations. The number of industrial gas applications ions in the gas distribution network can vary regionally from small to substantial***.***

The options and steps to be taken for blending hydrogen with natural gas are presented in the table below.

Overview of technical barriers for the component groups for the Netherlands

Component /hydrogen%	0.5	1	2	3	8	10	15	20	25	30	35	40	50	100
Process gas chromatograph / Measuring instrument														
Gas turbine[1]														
Natural gas as feedstock [2]														
CNG fuel station														
Domestic gas appliances *														
PPE[3] and tools														
Leak detection equipment														
Industrial burners[4]														
Gas pressure regulating stations														
Shut-off valves														
Gas flow meters														
Gas engines[5]														
House pressure regulators														
Gas pipes and . components														
Indoor gas pipes														

Status	**Legend**
Already possible	
Possible with suitable choice of equipment	
Modification settings / type approval	
Complete replacement or replacement of critical components	
Unknown, Need for further research	

** Existing appliances are only suitable for 3% hydrogen if safety aspects are covered for these appliances, for example by drawing up a risk analysis.*

Can a phased increase take place up to 20 vol% hydrogen in natural gas?
Discrete steps are possible up to 3, 8, 10 and 20 vol% hydrogen admixture, respectively.

What efforts must be made to realize the transition to hydrogen in the natural gas network?
If the content of hydrogen added to natural gas is higher than the currently permitted 0.5 vol% in RNB networks, an amendment to the regulations is necessary, including the Ministerial Regulation on Gas Quality.
When increasing to 20 vol% hydrogen, many devices (see overview table) will have to be readjusted.

[1] Depending on the type of control and the gas composition
[2] From 2% on it is recommended to remove the hydrogen from the gas
[3] Personal Protective Equipment
[4] Controlled burners suitable up to 5% and up to 50% with adjustment
[5] Depending on the type of control and the methane number of the natural gas

For the largest group of household users, further admixture of up to 20% by volume of hydrogen with natural gas is possible, if appliance types are used that have been declared suitable by the manufacturer for this hydrogen content.
The highest cost item in the transition is namely the replacement of non-depreciated gas consuming appliances that are not suitable for hydrogen admixture. At a content of 20 vol% hydrogen, it is necessary to adjust the current Wobbe limits for G-gas.. There are studies that indicate that many appliances are technically suitable for levels of hydrogen higher than 3 vol%. A study of the technical and legal consequences and the risks of blending hydrogen with natural gas for existing appliances can provide insight into the right policy choices.

A positive development is that recently three manufacturers have several types of boilers available that are suitable for 20 vol% hydrogen. A number of these device types have been sold for several years and some of the devices are therefore ready for levels varying from 0 to 20 vol% hydrogen. Further increase will be facilitated if more manufacturers follow and if other gas consuming appliances, such as geysers and cooking burners, are also declared suitable for this purpose. A large-scale introduction of these gas consuming appliances will lower replacement costs when a switch is made to hydrogen blending.

Further acceleration of the admixture of hydrogen to natural gas is possible by:

- monitoring the increase in the proportion of appliances that are suitable for hydrogen-containing gases
- encouraging manufacturers to issue a declaration of suitability for hydrogen-containing gases for existing appliances
- government policy aimed at accelerated modernization of the equipment park with appliances that are suitable for a broader gas quality, including hydrogen-containing gases.

Is it possible to blend more than 20 vol% hydrogen with natural gas?
Admixing up to a percentage of, for example, 50 vol% hydrogen is technically possible. In that case, the manufacturers will have to develop completely new central heating appliances and other gas applications (cooking appliances, stoves, etc.) in combination with adjustments to the applicable inspection standards and - following on from this - replacement of the existing appliances in the relevant network part. The question is whether these devices can handle the entire range from 0 to, for example, 50 vol% hydrogen. Up to now one appliance has been developed that can operate on both 100 vol% hydrogen and 100 vol% natural gas, but this is only possible after conversion by the installer.
The efforts and costs that have to be made for, for example, 50 vol% hydrogen distribution, are comparable to those for 100 vol% hydrogen distribution.
If sufficient hydrogen is available that it is desirable from a technical point of view to move to higher admixture levels than 20 vol%, the step to 100 vol% hydrogen distribution may be considered. Considerable one-off costs have to be incurred, namely the premature depreciation of the natural gas appliances, a possible surcharge for the first generation hydrogen appliances, the replacement of the gas meters and possibly the application of a new type of odorant.

What are the advantages of hydrogen admixture?
The hydrogen addition could already be applied in a relatively short term.
The infrastructural adjustments and costs are relatively low. In an earlier study “Future-proof gas networks” it was concluded that the current gas distribution network is suitable for hydrogen distribution. The advantage of this is that - at least in the case of sustainable hydrogen - the gas distribution is fully sustainable.
Adding 20 vol% sustainable hydrogen to fossil natural gas will replace 8.3 vol% natural gas. Taken together for all Dutch households, this would result in CO_2 savings of 1.3 billion kg and 7.7 billion kg, if all natural gas (including industrial applications) is

mixed with 20 vol%. This would make a significant contribution to the CO_2 reduction targets. An additional advantage is a reduction in CO emissions. The largest cost item concerns the accelerated depreciation of appliances that are not suitable for 20 vol% hydrogen.
The CO_2 saving at high hydrogen percentages grows more than proportionally and, moreover, with 100 vol% hydrogen combustion, no more CO emissions will occur from gas consuming appliances.

Do the aforementioned conclusions also apply to biomethane?
For hydrogen admixture with biomethane, the same conclusions apply as for adding hydrogen to natural gas, since biomethane is fully interchangeable with natural gas (G-gas) according to the Ministerial Regulation on Gas Quality. Because CO_2 is extracted from the gas in the production of green gas, it is a relatively simple process modification to extract even more CO_2 from the gas and thus increase the calorific value in order to make room for hydrogen addition. This may lead to a situation that the gas no longer meets the requirements for G-gas. This will result in a local gas quality.

Hydrogen can be added to enriched biogas (a mixture of carbon dioxide and methane). Still, this is a less logical route from a technical perspective, as the introduction of enriched biogas into the gas distribution network means that many of the current gas applications will have to be replaced and significant modifications to the natural gas network will also be necessary.